MORPHOLOGICAL CHARACTERS AS INDICATORS OF RUBBER CONTENT IN GUAYULE (*PARTHENIUM ARGENTATUM* – COMPOSITAE)

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ABSTRACT

Five distinct morphological groups were identified in a cultivated guayule stand at the Texas Agricultural Experiment Station Guayule Research Site near Fort Stockton, Texas. These groups were delineated according to growth habit, and leaf and inflorescence morphology. Mean rubber content was higher in Groups II, III, and V, which possessed more typical *Parthenium argentatum* morphological characters than in Groups I and IV. The latter groups are apparently products of the natural hybridization between guayule and mariola. Selection for superior rubber-yielding shrubs should be concentrated in Groups II, III, and V.

RESUMEN

Cinco diferentes grupos morfólogicos fueron identificados en un puesto de guayule cultivado en la Estacion del Estudioñ de Guayule de la Estacioñ Experimental de Agricultura de Texas. Estos grupos fueron delineados de acuerdo con lo alto y el diámetro del palio, caracteristicas de la hoja, y la morfologia del peduncio. El alto contenido de hule ocurrió en los Grupos II, III, y V los cuales poseen el tipico *Parthenium argentatum* de caractéres morfológicos. Los Grupos I y IV, productos de la hybridación natural entre el guayule y la mariola, producieron menos hule. La selección de arbustos que produscan hule superior deberá concentrarse en Grupos II, III, y V.

INTRODUCTION

The world supply of natural rubber comes from the tropical *Hevea brasiliensis* (Willd. ex A. Juss) Muell. Agr., and the United States imports almost one billion dollars worth annually from tropical Asia. Guayule (*Parthenium argentatum* Gray) is the most promising source of domestic rubber which can be successfully grown in the southwestern United States.

Guayule, a profusely branched shrub with small gray-green leaves, usually attains a height of 0.3 to 1 m (Correll and Johnston 1979). Native stands of this semidesert shrub occur in the Trans Pecos area of southwest Texas and northcentral Mexico at elevations of 700 to 2,000 m (Lloyd 1911). Guayule persists within a wide range of climatic tolerances where annual precipitation averages 25 to 38 cm and occurs primarily in late

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spring and early fall. Temperatures may vary from -23°C to 49°C (Foster and Moore 1987).

Lloyd (1911) described certain guayule biotypes growing in native stands in Mexico. Many of the plants had the mariola (*P. incanum* H.B.K.) growth form which is quite distinctive and easily identifiable. Rollins (1950) reported the existence of numerous biotypes of *P. argentatum* which differed widely in cultural characteristics, physiological behavior, and morphology. The differences were often traceable to the effects induced by interspecific hybridization between guayule and mariola.

Mehta et al. (1979) described different morphological forms of guayule collected from native guayule populations in Mexico. However, only three distinct types were delineated, and plant growth habit was not considered. Morphological and biochemical data indicated the presence of mariola genes in two groups, which correlated with an increase in leaf trichome length and a decrease in rubber content. The authors emphasized that high rubber-bearing plants in native stands could be selected by analyzing trichome morphology. Tipton and Gregg (1982) stated that since most native guayule was tetraploid and reproduced by facultative apomixis, seed collections based on leaf and inflorescence morphology should represent the germplasm originally selected.

The commercialization of guayule depends, in part, on the development of higher rubber-bearing shrubs through germplasm selection and plant breeding. Previous studies have yielded little definitive information on the interdependence of plant morphology and growth habit, and rubber content. The objectives of this research were to survey a 4 ha cultivated guayule stand established from seed collected from native Mexican populations and: (1) group the shrubs according to growth habit, and leaf and inflorescence morphology; (2) identify shrubs with rubber contents of at least 10%; and (3) determine if morphological characters were reliable indicators of rubber content.

MATERIALS AND METHODS

The study was conducted at the Texas Agricultural Experiment Station (TAES) Guayule Research Site located approximately 20 km west of Fort Stockton, Pecos County, Texas. The Firestone Tire and Rubber Company established about 80 ha of guayule in 1978, and leased it to TAES in 1983. Research was conducted in a 4 ha guayule stand established in 1981. The plants were grown in a greenhouse from seed collected at random in native guayule populations in Mexico, and transplanted into the field as eight-week-old seedlings. In addition to natural precipitation, the area received 13 cm of water annually by sprinkler irrigation.

Soil on the research area was a Delnorte very gravelly loam (loamy-skeletal, mixed, thermic family of shallow Typic Paleorthids) (Rives 1980). These are calcareous, light colored, very gravelly soils with indurated caliche within 50 cm of the surface.

The research area was surveyed in July 1986 and guayule shrubs were categorized into five distinct morphological groups based on growth habit, leaf shape and number of teeth, and branching of the peduncle. Fifty plants of each group were randomly selected and marked. Shrub height and two canopy diameter measurements were recorded. Ten leaves and peduncles were randomly collected from each plant, placed in a plant press, and returned to the laboratory. Terminology used in describing leaf characters follows Radford et al. (1974). The leaf shape and number of teeth on each margin, leaf length, and leaf width were recorded. Each peduncle was measured and the number of branches denoted.

In March 1987 and 1988, one branch from each shrub was harvested for resin and rubber analyses. The branches were air dried, defoliated and ground in a Fitzmill Comminutor with a 2.36 mm screen. Resin and rubber contents were determined according to the procedure outlined by Black et al. (1983).

Average plant height and canopy diameter, leaf length and width, and peduncle length are reported as the mean ± standard error. Resin and rubber values were analyzed by analysis of variance and the means were separated by Tukey's Studentized Range (HSD) Test ($\alpha = 0.05$).

RESULTS

Guayule plants in the five morphological groups varied considerably in growth habit (Fig. 1). The dense, intricately branched canopies of shrubs in Group I contained fine, tapered, smaller diameter stems similar to Group IV. Stems merged gradually into a peduncle, which branched two to three times. The branches were about the same length as the peduncle (Fig. 2). Leaves in Group I were smaller than other groups (Table 1). Leaf shape was usually oblanceolate to obovate, and the margins were coarsely toothed with two to four teeth (Fig. 2). Group I shrubs consistently produced lower rubber contents than Groups II, III, and IV (Table 2).

Group II shrubs were the tallest, reaching a mean height of 48 cm (Table 1). The canopies were open with minimal branching, and stem diameter was greater than in other groups. Unlike plants in Groups I and IV, there was an abrupt termination of the stem at the base of the peduncle. The naked peduncle generally branched once (rarely two times) with the branches extended beyond the peduncle (Fig. 2). Rubber content was significantly greater in Group II shrubs, and ranged from 7.2 to 13.1% in 1987 and from 6.2 to 12.0% in 1988.

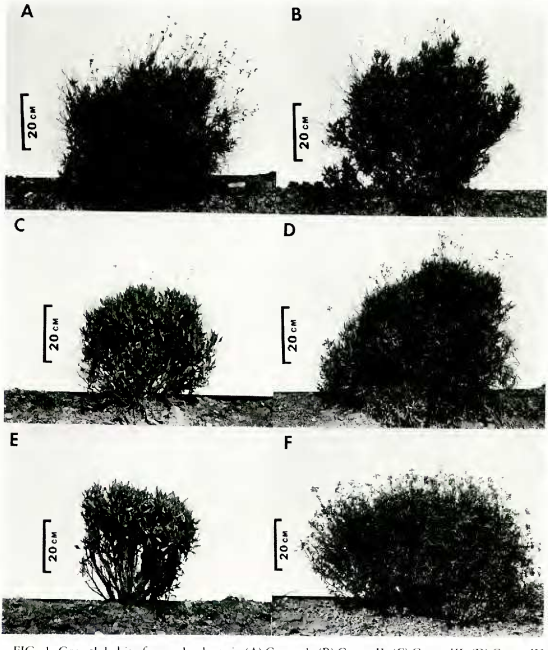

FIG. 1. Growth habit of guayule plants in (A) Group I, (B) Group II, (C) Group III, (D) Group IV, (E) GroupV, and (F) mariola.

Group III shrubs followed a low growth habit and resembled Group I in height and canopy diameter (Table 1). However, in Group III, the diverging system of larger branches resulted in a symmetrical, closely branched canopy, not the interwoven system as in Groups I and IV. Like Group II, the peduncle usually branched once (Fig. 2), the branch extended beyond the peduncle, and the distinction between stem and peduncle was abrupt. Leaves were intermediate in size compared to the other groups, and leaf shape and margin characteristics matched those in Groups II and V.

TABLE 1. Morphological characteristics of guayule shrubs within five morphological groups.

	Shrub		*Peduncle*		*Leaf*	
Group	*Height*	*Diameter*	*Length*	*Branches*	*Length*	*Width*
	(cm)		(cm)		(cm)	
I	39 ± 0.9[1]	54 ± 1.3	15.4 ± 0.1	2-3	3.5 ± 0.03	1.1 ± 0.01
II	48 ± 0.9	57 ± 1.2	14.0 ± 0.1	0-2	5.1 ± 0.04	1.2 ± 0.02
III	39 ± 0.8	52 ± 1.2	13.4 ± 0.1	0-1	4.5 ± 0.03	0.9 ± 0.01
IV	43 ± 0.7	64 ± 1.6	15.6 ± 0.1	2-3	4.5 ± 0.04	0.9 ± 0.01
V	46 ± 1.1	42 ± 1.2	14.8 ± 0.1	0-1	5.6 ± 0.04	1.0 ± 0.01

[1] Mean ± standard error.

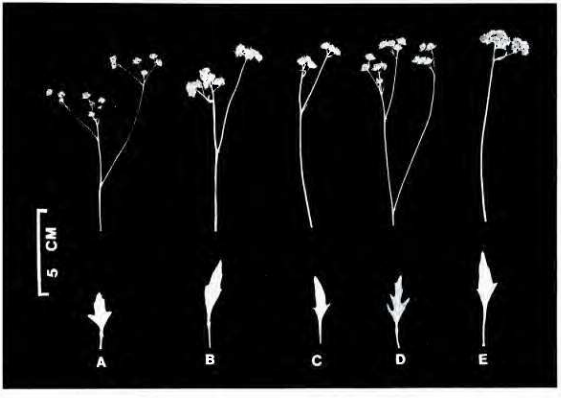

FIG. 2. Leaf and peduncle morphology in (A) Group I, (B) Group II, (C) Group III, (D) Group IV, and (E) Group V.

Canopy characteristics of Group IV shrubs were similar to Group I and included: (1) close, interwoven network of stems, (2) fine, tapered, small diameter stems, and (3) gradual transition of stem to peduncle. Leaf size was comparable to Group III; however, leaf shape was narrowly elliptic to elliptic (Table 1).

The growth habit and branching characteristics in Group V were similar to Group II (Fig. 1): plants were erect with an average height of 46 cm (Table 1); canopies were open with minimal branching; and stems termina-

ted abruptly at the base of the peduncle. Corresponding to Groups II and III, the peduncle generally branched only once with the branch extending above the peduncle. Mean rubber content of Groups II, III, and V was significantly greater than Groups I and IV (Table 2).

DISCUSSION

Lloyd (1911) stated that the monopodial growth of the guayule seedling was terminated by the development of the first inflorescence and followed by the rapid growth of several of the uppermost branches. The growth of these branches was also ended by the formation of an inflorescence. Thus, a constantly divaricating system of stems was produced, which resulted in a symmetrical, closely branched shrub. Through the failure of some branches to develop, irregular forms were often observed and attained a greater height than the symmetrical plants. Groups II and V were readily discernable in the field, and included upright, erect shrubs with less rebranching than other groups. Plants in Group III were low-growing with the symmetrical, closely branched growth habit.

As guayule leaves mature, they are characterized by a single tooth located near the middle of one margin (Lloyd 1911). Subsequently, a tooth appears on each margin, and a second pair can develop about halfway between the original two and the apex. The guayule stem, unlike mariola, terminates abruptly at the base of the peduncle, and the peduncles generally branch only once near the tip. The morphology of Groups II, III, and V was similar to these typical *P. argentatum* characters: (1) one to two teeth on either leaf margin, (2) peduncle branching one or two times with the branch extending beyond the peduncle, and (3) stems terminating abruptly at the base of the peduncle.

TABLE 2. Average resin and rubber content of guayule shrubs within five morphological groups harvested in March 1987 and 1988.

	Resin Content				*Rubber Content*			
	1987		*1988*		*1987*		*1988*	
Group	*Mean*	*Range*	*Mean*	*Range*	*Mean*	*Range*	*Mean*	*Range*
	(%)				(%)			
I	8.0b[1]	5.9-10.4	7.9b	5.4-12.2	5.5c	3.6-8.5	4.5e	1.9-8.0
II	8.2ab	5.5-11.1	8.1b	5.3-10.8	10.5a	7.2-13.1	9.4a	6.2-12.0
III	6.2c	4.6-9.4	6.3c	4.9-9.3	8.8b	5.0-11.3	8.7b	4.6-12.0
IV	8.1a	7.2-9.8	8.8a	6.8-10.6	6.1c	4.1-8.1	6.0d	3.7-7.9
V	7.9b	4.6-9.8	8.1b	5.1-11.0	8.8b	4.2-12.9	7.6c	3.1-11.8

[1] Means within columns followed by the same letter are not significantly different ($\alpha = 0.05$).

Groups I and IV, with dense, profusely-branched canopies, exhibited the mariola manner of growth, and apparently resulted from the introgression between guayule and mariola. Mariola stems, like guayule, terminate in an inflorescence, but are more slender and support short branches or spurs which are more numerous (Lloyd 1911). This manner of growth results in a close interweaving of stems, in striking contrast to guayule. Leaf morphology in Groups I and IV was intermediate between that of guayule and mariola. Leaves were oblanceolate/obovate and narrowly elliptic/elliptic in shape, and not the lanceolate/ovate shape typified by Groups II, III, and V. Morphology of the peduncle in the two groups resembled that of mariola. The peduncles usually branched two to three times and the branches were about the same length as the peduncle.

Results of this study confirm that guayule plants with morphology similar to *P. argentatum* (Groups II, III, and V) produced the highest rubber content. Selection should be concentrated in these groups with rubber contents of over 10%. Shrubs with the erect growth habit consistently yielded the greatest rubber content among the five groups. Shrubs with leaf and inflorescence morphology and growth habit similar to mariola should be avoided when screening plants for high rubber-bearing potential.

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